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CIRCULAR ON

THE UNDERGROUND

WATERS OF MISSISSIPPI

By W. N. LOGAN.



FIG. 1.—AN ARTESIAN WELL AT COLUMBUS, MISS.

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AGRICULTURAL COLLEGE, MISSISSIPPI.

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THE UNDERGROUND WATERS OF MISSISSIPPI

W. N. LOGAN.

INTRODUCTION.

The question of an available supply of potable water is one of vital importance to the citizens of our state. The questionable sanitary condition of the surface and shallow-well waters in many parts of the state has rendered the investigation of the availability of deep underground waters not alone desirable but, in many instances, imperative. An abundant supply of potable water may be considered one of the commonwealth's most valuable resources for upon it depends not only the physical well being of its people but also much of its material prosperity.

In general, deep underground waters are free from pollution from human sources and have this advantage over surface supplies. While other sources of infection, such as milk, oysters and other contaminated foods are admitted, impure drinking water is now conceded to be responsible, in the majority of instances, for the spread of typhoid fever. In all instances of recent investigation human pollution has been discovered and a removal of the source of pollution or the securing, by other means, of a supply of pure water has been the means, in every instance of checking the spread of the disease.

And although the mosquito theory for the transmission of malaria is now commonly accepted, nevertheless it has been found that in nearly every community where a change has been made from the use of surface or shallow-well water to deep underground water there has been a marked diminution in the number of malarial cases. It is probable that the use of such impure waters produces, on the constitution, an effect which renders the person more susceptible to disease. Consequently in nearly every instance in which pure underground water has taken the place of impure surface waters there has been a marked improvement in general health conditions.

ORIGIN OF UNDERGROUND WATERS.

The origin of the underground waters of Mississippi is precipitation. Of the water which falls upon the surface a part is evaporated,

a part, called the run-off, is carried away by the surface streams and a part sinks into the rocks and becomes the source of underground waters. Estimating the average annual rain-fall of the state at fifty-four inches the amount of water falling upon each square mile of surface is 125,516,800 cubic feet, or about 1,466,331 gallons per acre during each year. A large per cent. of this water percolates the rocks to form the supply of underground water. The underground waters of Mississippi flow in some pervious rock stratum toward the Gulf and doubtless ultimately mingle with the waters of that body as is true of the surface streams.

Purity.—The purity of underground waters depends upon a number of factors, chief among which are: Freedom of source from pollution; distance from source, depth, and character of super-incumbent rock. In investigating the purity of a water it is necessary to consider its environment as well as its bacteriological and chemical conditions. The impurities of underground waters may be classed as organic and inorganic. Deep underground waters usually contain but small quantities of organic impurities. It is possible, however, in the case of waters flowing through beds of rock containing large quantities of organic matter that some considerable quantities of such substances will be found in them. Such conditions exist in some of the Quaternary deposits of the Gulf coast and in some of the deep water-bearing strata of the Mississippi Bottoms. The majority of the shallow-well waters of the latter area also contain much organic matter. The amount of organic matter permissible in a potable water depends upon the character of the organic substances and the sources and environment of the water. In streams, shallow wells, or other surface sources of supply the presence of .10 parts albuminoid ammonia per million parts of water is looked upon with suspicion while .15 parts per million is deemed sufficient to condemn the water for drinking purposes. Organic matter as it usually occurs in underground water with the albuminoid ammonia it contains is not necessarily harmful. It becomes so, however, through its decomposition in the presence of bacterial growth. Proof of such decomposition will be established by the presence of any trace of nitrites, with considerable quantities of nitrates or free ammonia. Water from deep underground sources is not likely to be infested with objectionable germ growth and can be used with safety when fresh, although the presence of albuminoid ammonia and the discoloration of the water may indicate that it contains an abnormal quantity of organic matter. Such waters by standing in open containers become suitable culture media for bacteria and are thus rendered

unsafe as a source of water supply. They are for this reason never above suspicion.

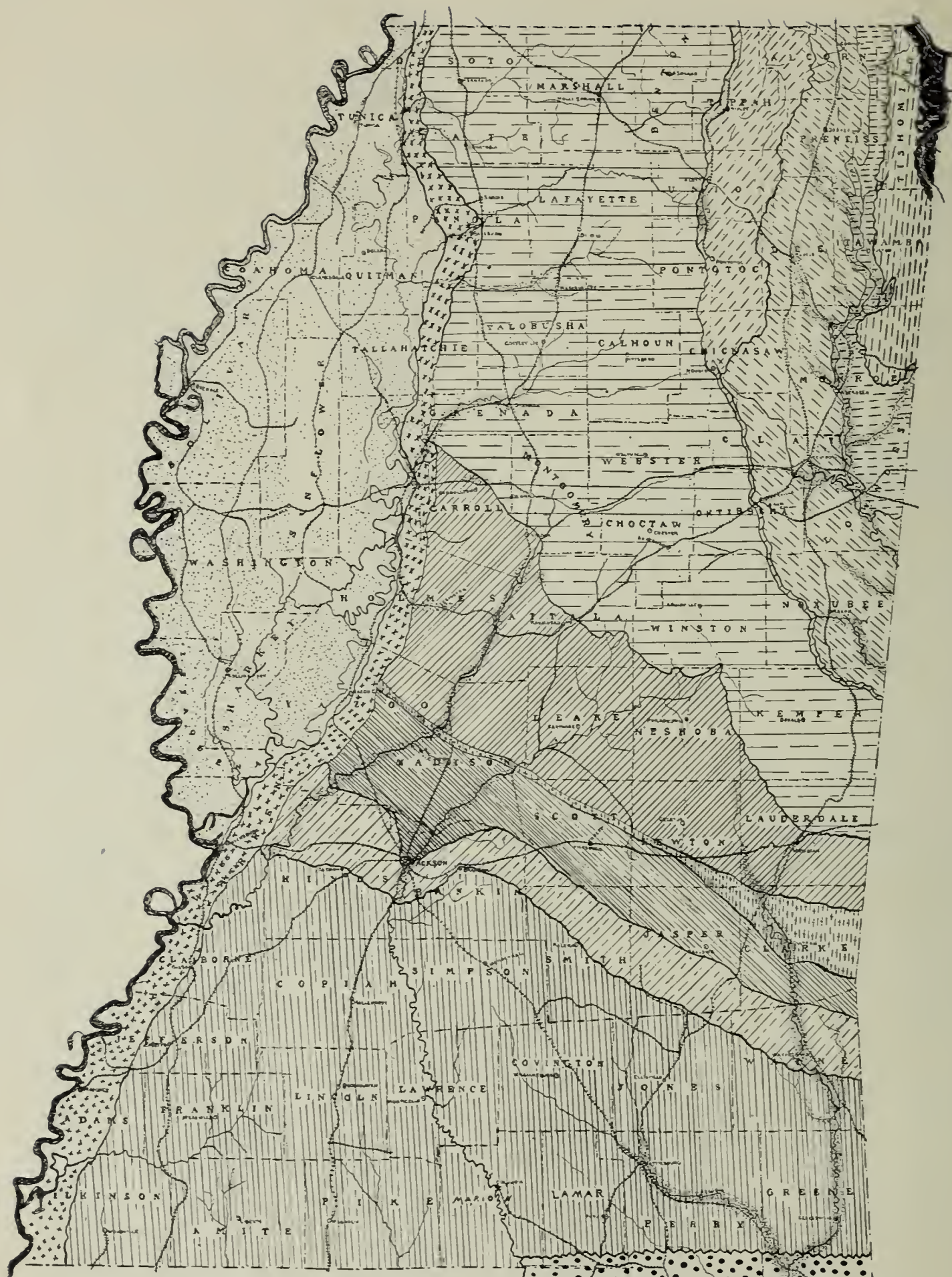
Organic Matter in Mississippi Deep-well Waters.—Analyses of waters from the following wells disclosed the presence of organic matter in the following amounts.:

	PARTS OF FREE AMMONIA PER MILLION.	PARTS OF ALBU- MINOID AMMONIA PER MILLION.
Columbus City Well	.18	.02
Hickory, Gallaspie Well	.50	.02
Waynesboro, Town Well.....	.76	.38
Tunica, Town Well	.08	.05
Clarksdale, 900-foot Well	.50	.05
Clarksdale, 330-foot Well	.60	.05
Clarksdale, 90-foot Well	.64	.04
Cleveland Well	.78	.06
Indianola Well	.128	.448
Ruleville Well	.455	.130
Doddsville Well	.144	.504
Sunflower Well.....	.18	.254
Leland Well	.29	.072
Greenville Well	.168	.032
Grenada Well	.555	.069

Inorganic Impurities.—The chemical elements most abundant in Mississippi underground waters are: Chlorine, sodium, carbon, calcium, magnesium, potassium, iron, sulphur, silica and phosphorous. These elements are combined to form such mineral compounds as sodium chloride, calcium chloride, magnesium chloride, potassium sulphate, magnesium carbonate, sodium carbonate, and calcium carbonate.

Classification of Mississippi underground waters.—The classification of Mississippi underground waters based upon the predominating ion will place the majority of the waters so far examined into one of three groups: 1. The soft water group, the waters of which contain less than ten grains of solid matter per gallon. 2. The carbonate group, in which the carbonate ion is the predominate one. 3. The chlor-carbonate group in which the chloride and carbonate ions are the predominate ones.

The Soft Water Group.—The waters from deep wells in the following places belong to the soft water group: Canton, Hickory, Greenwood, Batesville, Sardis, Senatobia, Lexington, Tunica, Leflore, Ackerman, Holly Springs, Water Valley, Riverside, Tupelo, Amory, Aberdeen, West Point (600-foot), Columbus, Cliftonville, Gulfport and Biloxi.



GEOLOGICAL MAP OF MISSISSIPPI.

- | | |
|----------------------------|----------------|
| Devonian And Carboniferous | Jackson |
| Potomac | Vicksburg |
| Tombigbee | Grand Gulf |
| Selma Chalk | Lafayette |
| Ripley | Port Hudson |
| Lignitic | Loess |
| Buhrstone | Alluvium |
| Claiborne | Artesian Areas |

The Carbonate Group.—The waters from the following wells may be classed as carbonate: Taylorsville, Ittabena, Cleveland, Yazoo City, Leland, Glendora, Durant, Tchula, Moorehead, Indianola, Ruleville, Doddsville, Sunflower, Dockery, Clarksdale, Artesia, Enterprise, Quitman and Shubuta.

The Chlor-carbonate Group.—To this group belong the waters from the following wells: Crawford, Starkville, Agricultural College, West Point (300-foot), Muldrow, Osborn, Macon, Ocean Springs, Scranton, Moss Point, Pass Christian, Lyon, Greenville, and Jackson (chlor-sulfo-carbonate group).

WATER - BEARING FORMATIONS.

The map on the preceding page presents the distribution of the principal geological formations of the state. With the exception of the alluvium of the Mississippi Bottoms no attempt has been made to outline the surficial formations. Only the southernmost extension of the Lafayette is represented, the broken line is intended to indicate that the formation has a more northern extension. The principal water-bearing strata are contained in the following formations of the state: Potomac, Tombigbee, Ripley, Lignitic (Lagrange), Buhrstone, Claiborne, Grand Gulf, Lafayette, and Port Hudson. The dotted areas on the map indicate the known and probable artesian areas for various parts of the state.

ARTESIAN WATER.

The essential conditions for an artesian well are, briefly stated, as follows: 1. A collecting ground or catchment basin located at some point higher than the mouth of the proposed artesian well.

2. A porous, inclined, rock stratum extending from the collecting ground to some point below the mouth of the proposed well.

3. The confinement of the porous stratum between impervious rock strata.

4. A well bore through which the water from the underground porous stratum may reach the surface.

When the water which falls upon the catchment area sinks into the porous layer its first tendency, under the influence of gravity, is to flow downward. The downward flow continues until an impervious stratum is reached. The water then flows along the surface of the impervious layer until a point is reached at which the influence of gravity is overcome by hydrostatic and rock pressure. At this point the water will rise toward the surface unless checked by an impervious layer. A well bore piercing the impervious layer at such a point will allow a

flow of water toward the surface and if the mouth of the bore has an altitude less than that of the catchment area a flowing well will be obtained.

The term "artesian water," as now used in the state, admits of two interpretations. The term is used by some people to designate water which rises in the well irrespective of whether it flows from the mouth of the well or not. By others it is used to designate flowing

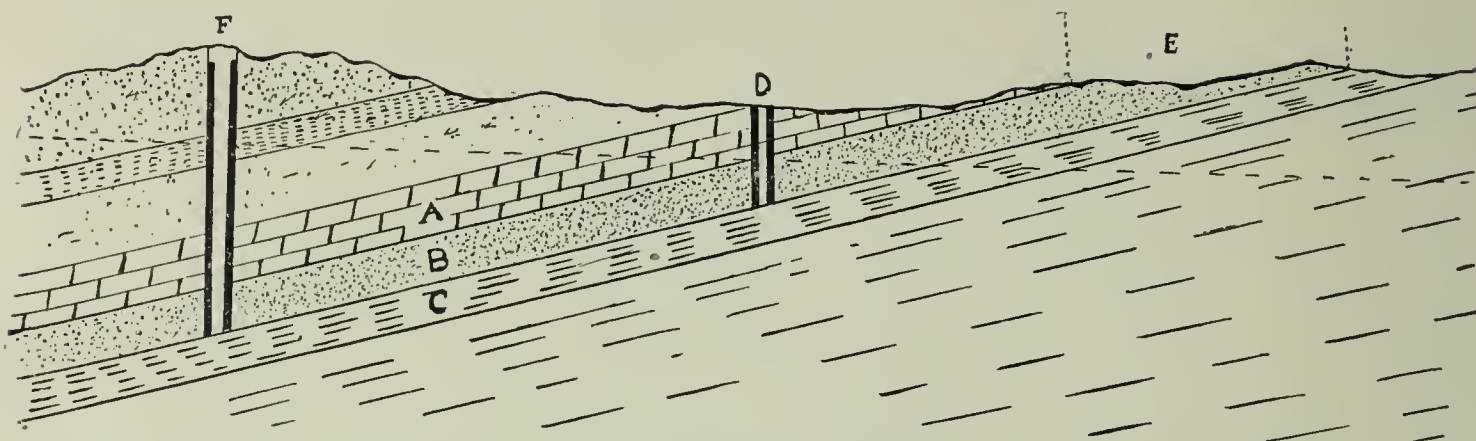


FIG. 2.—A DIAGRAM TO ILLUSTRATE ESSENTIAL ARTESIAN CONDITIONS. A and C., impervious layers; B, porous stratum; D, artesian well; E, collecting ground; F, non-flowing or hydraulic well.

water only. In order to avoid confusion the latter interpretation is given in this report and the term "hydraulic water" is used to designate the former class of waters.

In many areas of the state in which it is impossible to obtain flowing water on account of the altitude of the area, it is possible to obtain a good supply of water within pumping distance of the surface. Such an area exists in the western part of the Selma chalk outcrop, bordering the Tombigbee artesian basin. It is possible for one conversant with the geological conditions at a given point to estimate the depth at which water may be obtained and the height to which it will rise in the well providing the altitude and the geographical position of the place be given. The cost of the well may also be computed when the depth is obtained and the character of the rocks is known.

ARTESIAN AREAS OF MISSISSIPPI.

The Northeastern Area.—The artesian area of this region includes most of the low lands along the Tombigbee river and its tributaries. The wells on the higher lands west of the Tombigbee are not artesian but hydraulic, the water rising in most instances within easy pumping distances of the surface. The wells of the area vary in depth from 150 feet to 1000 feet, being deepest in the southern and southwestern portions of the Selma chalk area. There are two principal water-bearing strata. The lower belongs to the Potomac and the upper to



FIG. 3.—AN ARTESIAN WELL AT TUPELO, MISS.



FIG. 4.—PARK LAKE AT TUPELO, MISS. Supplied with water from| five
artesian wells.

the Tombigbee formations. They are separated at West Point by about 300 feet of sands and clays. The upper stratum is reached at Starkville at a depth of 900 feet and at a depth of 910 feet at Shuqualak. On account of the westward or southwestward dip of the stratum it soon becomes inaccessible in the Flatwoods. In the northern part of the state, however, a still higher water-bearing stratum, the Ripley, becomes accessible for the eastern part of the Flatwoods from Houston to the state line. There is also a small artesian basin in the Ripley outcrop, the wells varying in depth from 90 to 500 feet.

The Eastern Area.—The artesian basin of the eastern portion of Mississippi is included in the low lands along the Chickasawhay and the Leaf rivers. The higher lands furnish non-flowing but deep hydraulic wells. The principal water-bearing strata belong to the Buhrstone, the Claiborne and the Grand Gulf formations. The artesian wells vary in depth from 150 to 600 feet. Some of the hydraulic wells reach available water at 1500 feet.

The Gulf Coast Area.—This artesian area includes besides the low lands along the coast the lower valleys of the Pearl and the Pascagoula rivers. The geological formations of the Coast consist of fresh and brackish water sands, clays, and gravels, and marine sands and muds. Water-bearing sands and gravels occur at a number of horizons. Two water-bearing strata were encountered in the wells at Bay St. Louis, Lyman, Moss Point and Biloxi. At Slidell, La., there are three water-bearing strata. The first at 300 feet, the water flowing ten gallons per minute; the second at 450 feet, the water flowing 60 gallons per minute; the third at 900 feet, the water flowing 80 gallons per minute.

The water-bearing strata of the Coast extend outward underneath the waters of Mississippi Sound toward the deep waters of the Gulf. At Gulfport and at Bay St. Louis potable artesian water is obtained from strata underlying the marine waters of the sound. At Ship Island which lies about eleven miles out in the sound, south of Biloxi, artesian water is obtained at a depth of 750 feet. At Biloxi the first important artesian water is obtained at a depth of 500 feet. If this is the same stratum from which the water is obtained on Ship Island the dip of the stratum Gulfward is about 21 feet per mile.

The Mississippi Bottoms Area.—Doubtless the greater part of the area included between the Yazoo and the Mississippi rivers will furnish artesian water at an available depth. The artesian wells now in existence vary in depth from 90 to 1320 feet. In some localities as many as three water-bearing strata have been encountered in the wells. For instance at Clarksdale water is obtained at 90, 330 and 900 feet.

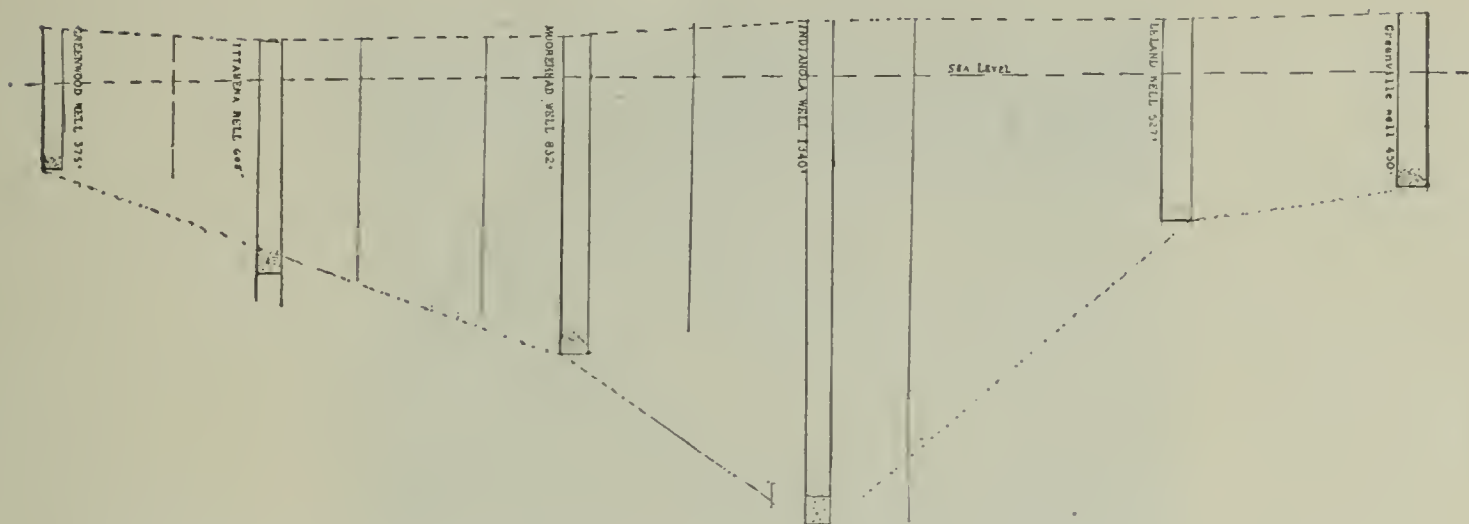


FIG. 5.—SECTION, SHOWING DEPTH OF WELLS between Greenwood and Greenville, Miss.

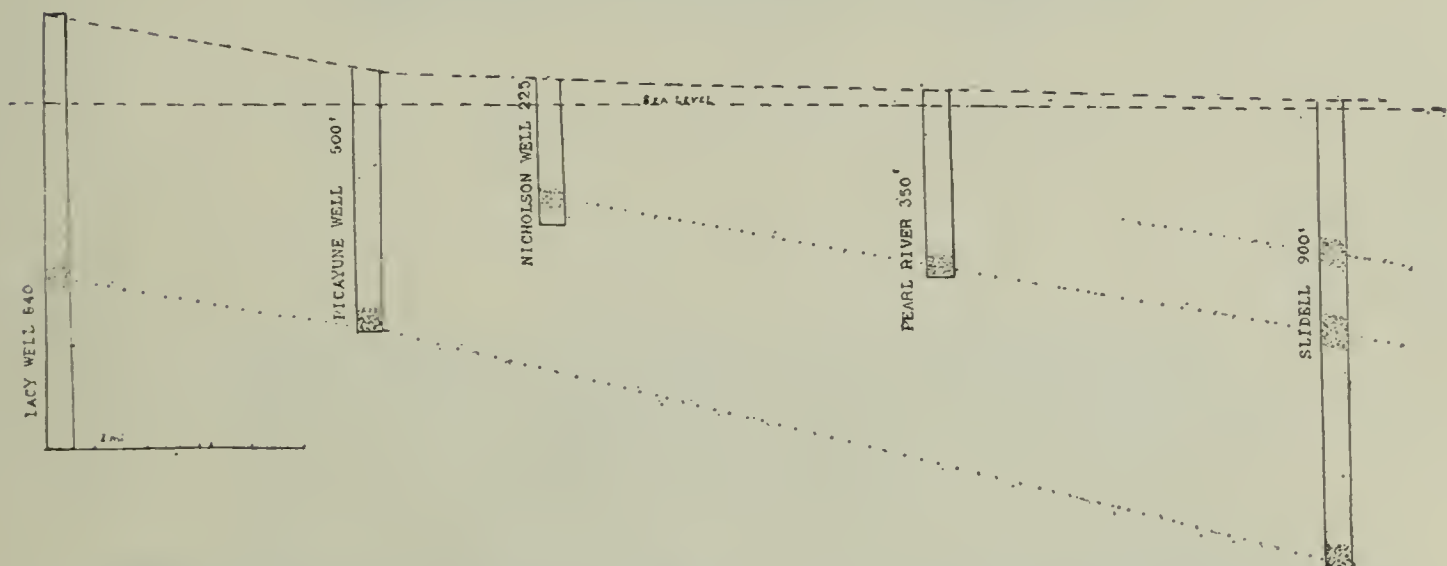


FIG. 6.—SECTION FROM LACY, MISS., TO SLIDELL, LA., showing position of water-bearing strata.

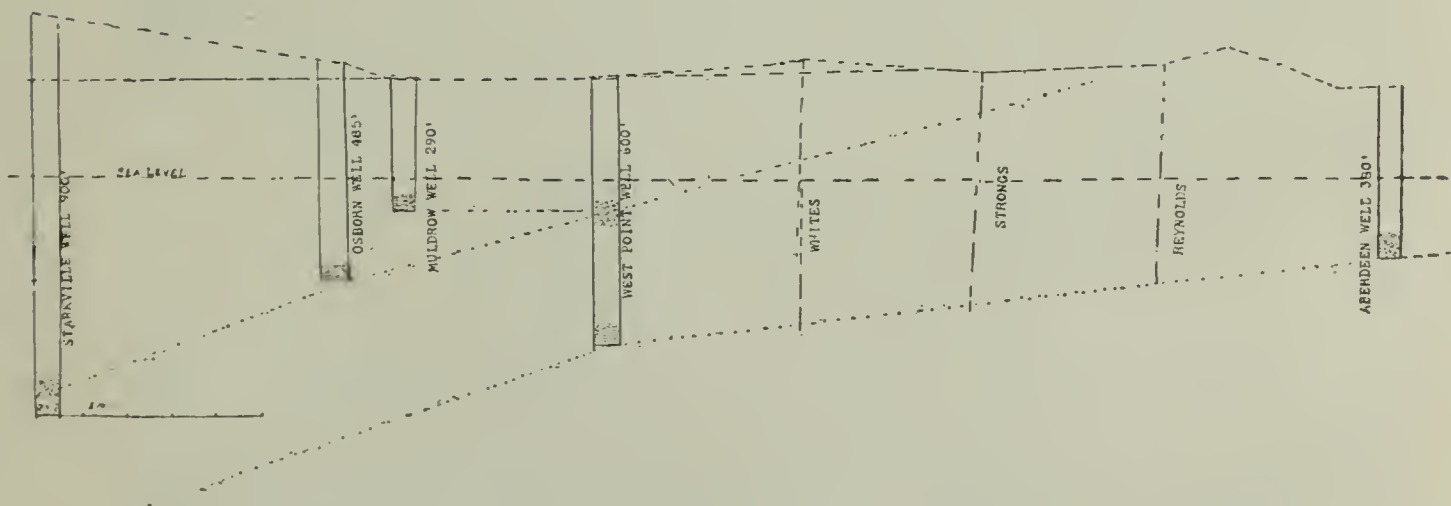


FIG. 7.—SECTION FROM STARKVILLE TO ABERDEEN, showing depth of water-bearing strata.



FIG. 8.—ARTESIAN WELL AT ENTERPRISE, MISS.

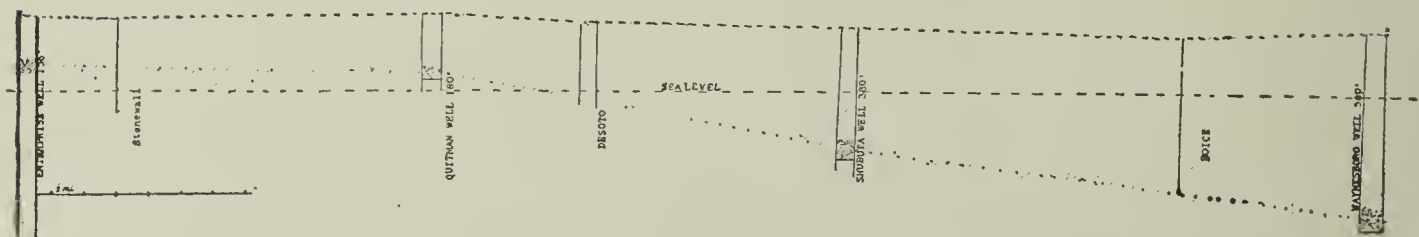


FIG. 9.—SECTION FROM ENTERPRISE TO WAYNESBORO, showing depth of water-bearing strata.



FIG. 10.—AN ARTESIAN FOUNTAIN AT BILOXI, MISS.



FIG. 11.—AN ARTESIAN WELL AT HATTIESBURG, MISS.



FIG. 12.—PALOL SPRINGS, NEAR HATTIESBURG, MISS.

WELL DRILLING.

Methods of Drilling.—In the drilling of shallow wells a bit or churn drill is rotated in an iron casing. The bit serves to loosen the earth which is removed from the bore by means of a pump or long cylindrical bucket with a valve in the bottom, water being first forced into the casing.

For wells of greater depth, in which this method is impracticable, a hollow revolving bit is used. After the earth has been loosened by the bit it is removed from the bore by means of an upward current of water which is maintained between the bit and the wall of the bore by forcing water down the hollow bit and allowing it to escape through an opening just above the point of the bit. The power used for drilling may be hand power, horse power, or steam power, depending on the size and depth of the well. This process is called the "jetting process."

In the rotary process no casing is used but a bit larger than the hollow-bit-pipe is provided with a mechanical device for rotating it by steam power. In case the bore is passing through sand or incoherent sandstone water containing considerable clay is forced into the hollow pipe for the purpose of making the walls of the bore more firm. Since the size of the bore is larger than the bit-pipe, the water carrying the drillings is forced upward between the bit-pipe and the wall of the bore. After the bore has reached the water-bearing stratum the bit and pipe are removed and the well is cased if the bore is in sand or other undurate rock. If in firm rock, casing is not needed. In passing through hard and soft strata only the section of soft rock is cased. In some wells a perforated pipe or strainer is used to keep out the fine sand. Some wells are pumped for several days after the water-bearing stratum is reached in order to remove the sand and form a basin at the base of the bore. In gravel or coarse sand no strainer is needed. In some instances a surface settling basin is used in order to free the water from suspended particles.

For drilling wells of from three to five hundred feet in depth portable drilling outfits consisting usually of a traction or dummy engine, a derrick and a pump is used. For drilling wells reaching greater depths a stronger outfit is desirable. A taller, stronger derrick than the portable one is used so that two or even three lengths of pipe or casing may be uncoupled at a time.

Cost of Deep Wells.—The cost of a drilled well depends upon a number of factors such as the depth, character of the rock, and the kind of drill. Some well drillers now at work in the state make a charge of fifty cents per foot for the first 300 feet and for each additional 100 feet



FIG. 13.—A WELL DRILLER'S OUTFIT.

the rate increases twenty-five cents per foot. At this rate the average cost per foot of a 500-foot well is sixty-five cents. The average cost per foot of a 1000-foot well is \$1.20.

In some localities where the softness of the rock is well known a uniform rate of forty cents per foot to a depth of five hundred feet is charged. In strata of incoherent sands the cost of deep wells is increased by the necessity for casing.

In firm rock such as limestone, or even in clay, casing is rarely needed. The following examples are of wells which have been put down in different parts of the state and will serve to give some idea of the cost of deep wells:

WELL No. 1. Depth, 522 feet; cost, \$208.80; character of the rock, sand and sandy marl.

WELL No. 2. Depth, 607 feet; cost \$357; character of rock, limestone, sand and clay.

WELL No. 3. Depth, 210 feet; cost, \$75; character of rock, sand and clay.

WELL No. 4. Depth, 814 feet; cost, \$582.50; character of the rock, limestone, clay and sandstone.

For a more complete discussion of the underground waters of Mississippi see bulletin No. 89, "The Underground Waters of Mississippi," by W. N. Logan and W. R. Perkins, of which this Circular is largely a summary.



FIG. 14.—WELL DERRICK AT ENTERPRISE, MISS.



FIG. 15.—THE IUKA SPRINGS.